WR-1 I49.89: 82/61

FWS/OBS-82/61
August 1984

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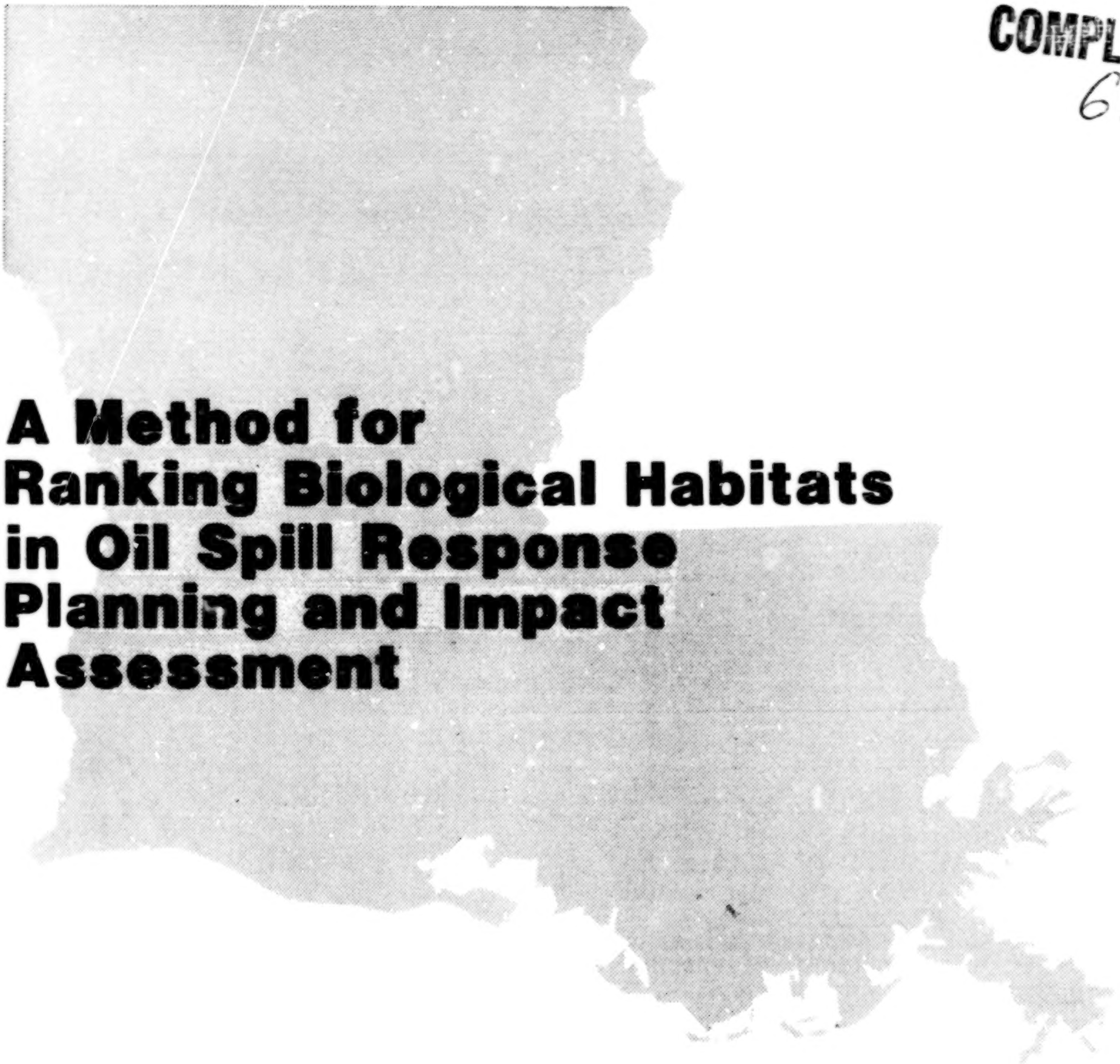

A Method for Ranking Biological Habitats in Oil Spill Response Planning and Impact Assessment

Fish and Wildlife Service
U.S. Department of the Interior

FWS/OBS-82/61
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A Method for Ranking Biological Habitats in Oil Spill Response Planning and Impact Assessment

by

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Division of Biological Services
Research and Development
Fish and Wildlife Service
U.S. Department of the Interior
Washington, DC 20240

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Library of Congress Catalog Number: LC84-601103

This report should be cited as:

Adams, J.K., K.A. Benkert, C. Keller, and R. White. 1984. A method for ranking biological habitats in oil spill response planning and impact assessment. U.S. Fish Wildl. Serv. FWS/OBS-82/61. 42 pp.

PREFACE

The following report describes a method that enables oil spill response planners to minimize the ecological impacts of oil spills by determining protection priorities for biological habitats. The objective of the method is to allow persons responding to an oil spill to quickly identify areas that should be protected first, second, and on to the extent that personnel and equipment are available. The first part of the report describes the rationale and general components of the method. The last part presents an application of the method to the Louisiana Offshore Oil Port (LOOP) spill response planning area.

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INTRODUCTION

Clearly, one objective in the evolution of petroleum production and transportation technology is to minimize environmental risks due to accidents. Nevertheless, an occasional accident will result in the release of oil into the natural environment. Oil spill contingency planning provides an _a priori_ mechanism for agreed upon approaches to spill contaminant and cleanup in an effort to avoid the conflict that arises when goals are ill defined.

Lindstedt-Siva (1979a) argued that the primary goal of oil spill response should not simply be to remove visible oil, but rather to minimize the ecological impacts of oil spills. She outlined three general requirements of an effective spill response plan: identification and prioritization of areas sensitive to oil, development of strategies for the protection of these areas, and the development of spill cleanup guidelines whose goal is to minimize overall ecological damage.

The purpose of this report is to document and demonstrate a method to accomplish the first requirement, the identification and prioritization of geographic areas based upon their response to oiling. Our goal is to present a method that will be (1) driven by the existing information base, (2) applicable to all coastal and aquatic environments, and (3) capable of producing a prioritization within a specific spill response planning area.

RATIONALE AND DESCRIPTION OF HABITAT RANKING METHOD

RANKING UNITS

The first consideration in the analysis of the sensitivity of biological systems to oil spills is to establish and identify the analytical units to be ranked. To be useful in oil spill response planning, these units should be ecologically sound, geographically delineable, and capable of being classified as to the relative importance of the damage to them caused by oiling. The "habitat" was selected as the best available unit for this purpose.

The term "habitat" refers to the place occupied by an entire community of organisms; it has geographic boundaries that can be measured and mapped. It is important to note that the structure of this living space may be composed of biotic (salt marsh) or abiotic (beach) material. The importance of this distinction will be discussed below.

The attributes of habitats that make them useful analytical units include as follows:

1. They are landscape units whose boundaries can be defined and whose areal extent can be determined.
2. An assessment of the effects of oil can be made for a small representative habitat area, and the results extrapolated to larger or similar habitats elsewhere.
3. Because a habitat is an irreducible requirement of a species, changes in the life support value of the habitat caused by oiling can be expected to result in population shifts for species of interest.

To use habitats as the basic analytical units in spill response planning, a system must be available for identifying and labeling the habitats within a selected study area. Accurate, large-scale habitat maps are a must for effective spill response planning. If they are not already available for the area of interest, habitat maps can be readily compiled from aerial photographs with ground-truth verification. The method of classification used for spill response planning should be related to the human-scale, operational nature of spill response. The habitat units should be major landscape features that are sufficiently defined to be used by the untrained observer. The classification system developed by Cowardin et al. (1979) is a detailed classification system for the wetlands and deepwater habitats of the United States. Much of the coastal United States has been mapped according to this system. Numerous regional classification systems are also available; however, maps at a scale suitable for spill response planning have not been compiled using these systems.

A list of generic habitat types is presented in Figure 1. These were derived from the list provided by Cowardin et al. (1979) and are more fully defined therein. Only coastal and aquatic habitats are considered for treatment by this method.

RANKING CRITERIA

Once the analytical units have been defined and selected for a particular spill response area, it is necessary to select the criteria by which these units differ with regard to the overall impact of oil spills. To be generally useful, these criteria should be relevant to minimizing ecological damage, easily determined from the existing information base, flexible enough to incorporate new information, and capable of a basic differentiation between the analytical units. Since habitats have been selected as the analytical units, the criteria must be stated in terms of observable qualities of a habitat. The criteria selected are:

- Time period for the structural recovery of a habitat from oiling (habitat recovery)
- Time period that oil persists within a habitat (persistence of oil)
- Degree of damage to a habitat resulting from attempted cleanup (cleanup damage)
- Rarity of the habitat type expressed as area (habitat rarity)
- Number of important species supported by a habitat (important species supported).

The criteria are individually defined in the following section.

Habitat Recovery

This criterion assesses the time required for a habitat to regain its prespill structural completeness and complexity. Although habitats composed of abiotic structures (such as beaches, rocky shores, and open water) have productive biological communities that depend on them, their basic physical structure can remain intact after oiling and can be repopulated in a relatively short time. Habitats where structure is determined primarily through vegetation (such as marshes, swamps, and beds of aquatic vegetation) will vary considerably in the time period required for recovery from destruction due to oiling. It is important to note that this observable criterion integrates a

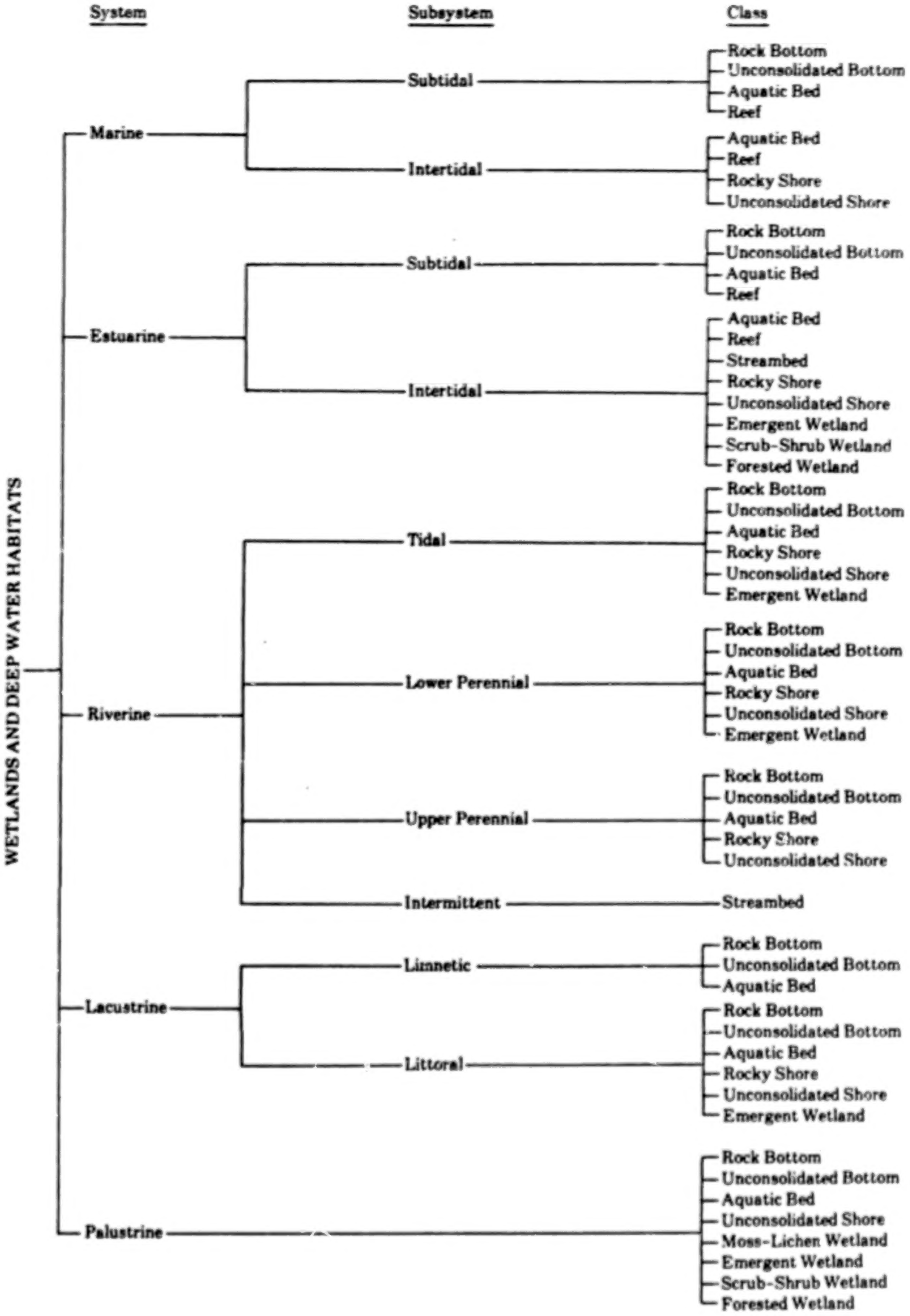

Figure 1. Classification hierarchy of wetlands and deepwater habitats, showing systems, subsystems, and classes. The Palustrine System does not include deepwater habitats (from Cowardin et al. 1979).

complex of interactions between oil and habitat. The longer the recovery period, the more protection a habitat should be afforded.

Persistence of Oil

The potential for cumulative biological harm is related to the length of time that oil remains within a habitat in contact with resident species. This time period depends primarily upon the kinetic energy level (wind, waves, currents) of a habitat and its geomorphology. Other factors that influence *in situ* weathering (a complex of physical, chemical, and biological processes by which oil is ultimately converted to carbon dioxide, water, and biomass) can also affect the persistence period. Because habitats that exist within varying energy regimes, are composed of various substrates, and their communities have varying biodegradation potentials, the persistence of oil can make a distinction between habitats. The evaluation of this criterion is based upon the duration of observable oil within a habitat.

Cleanup Damage

Although some sort of cleanup technique has been developed for most habitats and "ease of cleanup" has been used by others in developing protection strategies (Lindstedt-Siva 1981), attempts to clean up oil spills can cause extensive ecological damage within a habitat. The degree of damage will vary with the habitat type and the cleanup method. Habitats that would be harmed by existing state-of-the-art techniques should receive greater consideration for protection than those for which reasonably safe cleanup techniques are available. This criterion can be differentiated among habitat types based on the reported observations of habitat disruption resulting from cleanup operations.

Habitat Rarity

Diversity in number of habitats is ecologically important because of the broad interconnections and energy transfers occurring through the life history requirements of individual species that often utilize resources in more than one habitat. If all habitats are equally vulnerable, the area of a habitat type within a planning region controls the probability of its total loss due to oiling. Habitats comprising a small fraction of the total planning area could be completely removed from an ecosystem by a single spill incident. Therefore, the rarer habitat types should be given greater consideration for protection than the more common ones. An objective evaluation of this criterion can be obtained by computing the percentage of the total planning area occupied by each habitat.

Important Species Supported

Important species are defined here as those recognized through some social mechanism to have distinct value to man. We include in this grouping endangered species, commercially important species, and recreationally important species such as sport fish and birds. Habitats vary in the support they provide to these species, and this variation forms an additional basis of habitat differentiation for spill protection. Greater consideration for protection should be given to habitats that support many important species than to habitats that support few. This is a straightforward determination which is derived from literature on the habitat requirements of these high-profile species.

HABITAT PRIORITIZATION

Once the two fields of "habitats" and "criteria" have been defined, a set of observations is required that will allow a description of the interrelationships between them and the establishment of a clear-cut pattern for spill protection priority ranking. Published literature relating to oil spills is voluminous. Many case studies contain observations directly relevant to the determination of habitat ranking. Valuable information may also be obtained from biologists who are experienced in oil spill response. Then, together with areal habitat measurements and literature about habitats of high-profile species, an information base for habitat ranking is formed.

Access to the published information base is straightforward and must be expressed in terms compatible with the ranking criteria. To access the experiential information base, biologists with oil spill experience in the habitats within the planning area must be polled. One way to accomplish this is through a questionnaire formatted in the same habitat/criterion framework as the literature review.

From an interpretation of the literature and an analysis of the questionnaire responses, a value can be given to each criterion for each habitat. Considering the present state of knowledge, a rating of 1 (low), 2 (medium), or 3 (high) is justifiable and sufficient to establish a relative ranking.

Once the ratings of a habitat for each criterion are established and compiled, these are averaged to compute an overall criterion value for that habitat. The values for the five criteria are then totalled to give a relative ranking value for each habitat. This assumes an equal weight for each criterion because weighting was not deemed justifiable given the current state of knowledge. If subjective weighting is deemed desirable by resource managers within a planning area, multipliers could be used.

Through the above steps, an information base is expressed in a format useful to spill response personnel. An application of this methodology to a concrete spill response planning problem is demonstrated in the following.

APPLICATION OF HABITAT RANKING METHOD

PLANNING AREA

The Louisiana Offshore Oil Port (LOOP) is the first deepwater oil port to be permitted in the United States. It consists of a marine terminal, offshore and onshore pipelines, and storage facilities. Crude oil for the port is expected to come from the North Sea and several countries in the Middle East. During the first full year of operation an estimated 330 ships will unload at the facility (Zwirbla et al. 1980).

Due to its geographic expanse and the ecological diversity of the locale, the LOOP project area presents a challenging problem for spill contingency planners. LOOP's oil spill contingency plans address the potential of spills occurring in both freshwater and saltwater habitats. In this analysis, these habitat groups have been dealt with separately because it is unlikely that a single spill resulting from this facility would affect both.

The LOOP area of interest for spill response planning encompasses approximately 3200 m^2 (829,000 ha) and includes four major estuarine ecosystems: Barataria Bay, Timbalier-Terrebone Bays, Atchafalaya Bay, and Vermilion-Cote Blanche Bays (Figure 2).

Processes such as water movement, land surface subsidence, biological activity, and human technology work upon the geologic elements of sands, silts, and clays to shape the ever-changing quality and form of this region. Seasonal river floods, primarily diurnal tides (range 40 cm or 16 inches), longshore currents, and winds (including frontal passages and hurricanes) maintain the shallow nearshore and estuarine open water systems in a relatively turbid and morphologically dynamic state, while wetland and aquatic vegetation provide a stabilizing factor which serves to maintain balance and order within the region. The tremendous biological productivity of this region is exemplified by the unparalleled annual commercial fishery and recreational waterfowl harvests. Every habitat within the planning area supports some biological resource that local human populations utilize either directly or indirectly. Thus, the LOOP spill response planners require a priority ranking of biological habitats for spill protection that is specific to their planning area.

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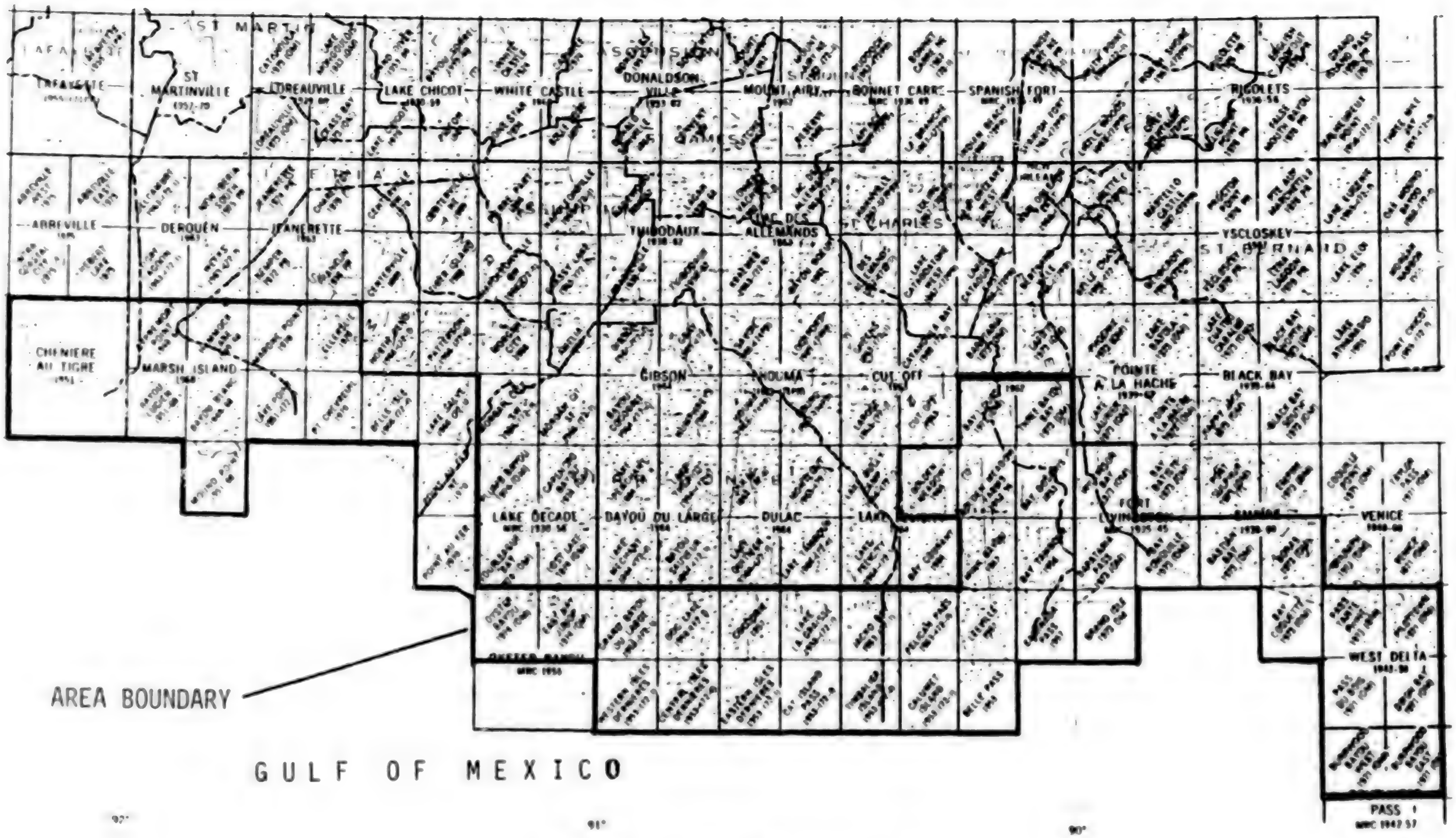

Figure 2. LOOP planning area.

ASSUMPTIONS

Due to the complexity of the possible interactions between spilled oil and the environment, it is necessary to make simplifying assumptions to develop contingency plans. In this ranking exercise, the following assumptions were made:

1. The spill of concern is a massive spill capable of impacting many habitats with significant oiling.
2. With regard to the development of a protection strategy, the spilled oil is treated as a surface phenomenon.
3. Each habitat type has an equal probability of being oiled.

HABITATS

Detailed habitat maps of the entire planning area at a scale of 1:24,000 facilitated the selection and quantification of habitats for analysis (Wicker, et al. 1980). Since these habitats were delineated at a more detailed level of classification than required, they were grouped into more basic habitat types (see Appendix A). The area for each habitat and percentage of the total area are presented in Table 1. A description of each habitat type as it occurs within the LOOP planning area is given below.

Saltwater Swamp

Moderate to dense growth of usually stunted (3m or 10 ft) black mangrove trees (*Avicennia germinans*) occurring as fringe vegetation along the outer shoreline, as extensive thickets on the sound side of some barrier islands (especially Isles Dernieres), and intermixed with *Spartina alterniflora* in salt marshes. The saltwort (*Batis maritima*) is a commonly associated species.

Brackish Marsh

A marsh of moderate salinity containing dense stands of wire grass (*Spartina patens*), three-cornered grass (*Scirpus olneyi*), coco (*Scirpus robustus*); or a marsh of low salinity containing dense stands of sawgrass (*Cladium jamaicense*), Walter's millet (*Echinochloa walteri*), bullwhip (*Scirpus californicus*), roseau cane (*Phragmites australis*), or cattail (*Typha* sp.)

Saltwater Marsh

High salinity marshes composed of dense stands of grasses, especially oystergrass (*Spartina alterniflora*), blackrush (*Juncus roemerianus*), saltwort (*Batis maritima*), and saltgrass (*Distichlis spicata*).

Table 1. Area of each habitat and percentage of total within the LOOP planning area.

Habitats	Area (ha)	Percent
Saltwater habitats		
Saltwater swamp	2720	0.34
Brackish marsh	92696	11.74
Saltwater marsh	79254	10.04
Saltwater aquatic bed	2285	0.29
Mud/sand flats	2073	0.26
Estuarine open water	608973	77.14
Sand beach	1043	0.13
Shell beach	417	0.06
Freshwater habitats		
Freshwater swamp	9096	17.62
Freshwater marsh	37778	73.17
Freshwater aquatic bed	248	0.48
Fresh open water	4510	8.73

Saltwater Aquatic Bed

Sea-grass beds composed primarily of widgeon grass (*Ruppia maritima*); most abundant in small ponds located in the brackish marsh; wild celery (*Vallisneria* sp.) is a common associate.

Mud/Sand Flats

Nonvegetated intertidal zone with low wave and tidal energy regimes and sand, mud, or organic substrate; includes washover fans behind barrier islands, areas subject to shallow-water flooding, and depositional environments within protected marsh areas.

Estuarine Open Water

All open water bodies within the planning area that have salinities of 0.5 ppt or greater during the period of average annual low flow.

Sand Beach

Wave reworked intertidal sand materials along a land-water interface; most commonly found along the gulfward side of the barrier islands.

Shell Beach

Wave reworked intertidal shell, predominantly of the American oyster (*Crassostrea virginica*); found mostly along retreating marsh shorelines in depositional environments; common between Marsh Island and Point Au Fer.

Freshwater Swamp

Predominantly contains medium to dense stands of cypress (*Taxodium distichum*) and tupelo gum (*Nyssa aquatica*) with a relatively sparse understory of shrubs, vines, and herbs; may also include bottomland hardwoods.

Freshwater Marsh

Dominated by dense stands of maidencane (*Panicum hemitomon*), pennywort (*Hydrocotyle* sp.), pickerelweed (*Pontederia cordata*), alligatorweed (*Alternanthera philoxeroides*), and bull tongue (*Sagittaria* sp.).

Freshwater Aquatic Bed

Free-floating herbs such as water hyacinth (*Eichhornia crassipes*) and rooted aquatic herbs such as water lilies (*Nymphaea* sp.) occurring in dense, sometimes scattered stands; often with abundant masses of filamentous algae attached.

Fresh Open Water

A relatively shallow body of fresh water with emergent vegetation absent; includes natural lakes, ponds, streams, and artificial bodies of freshwater.

CRITERIA EVALUATION

The following evaluation system was devised to differentiate the habitats by the selected criteria. These were chosen by analyzing the distribution of questionnaire responses or values in the literature reported for all habitats and distilling these into a range of low (1), medium (2), or high (3). By using the values 1, 2, and 3, the total of the five criteria for each habitat results in a possible range of 5 to 15. The choice of numerical values to use was arbitrary. Use of larger values would have spread the range of totals but would not have affected the rank. The criteria and the values assigned are described in Table 2.

RESULTS AND DISCUSSION

The resulting habitat ratings for recovery period, oil persistence, and cleanup damage are presented in Tables 3, 4, and 5. If data were not available to assign a value to each habitat, an assumed rating was made. The concentration of oil industry activities in the coastal zone was reflected in the relatively small amount of data available on oil spills in freshwater habitats. Consequently, it was necessary to assign saltwater habitat values to

Table 2. Ranking criteria.

Criterion description	Range	Value	Description of range
Time period for structural recovery of a habitat due to oiling	Low	1	1 year or less
	Medium	2	Between 1 and 3 years
	High	3	Greater than 3 years
Time period oil persists within a habitat	Low	1	1 year or less
	Medium	2	Between 1 and 3 years
	High	3	Greater than 3 years
Degree of damage to a habitat resulting from attempted cleanup	Low	1	Cleanup can be accomplished with little or no further damage
	Medium	2	Cleanup causes moderate habitat destruction
	High	3	Cleanup causes extensive habitat destruction
Number of important species supported by a habitat	Low	1	0% to 25% of a category
	Medium	2	26% to 50% of a category
	High	3	51% to 100% of a category
Rarity of the habitat type	Low	1	51% to 100% of total area
	Medium	2	11% to 50% of total area
	High	3	0% to 10% of total area

corresponding freshwater habitats. Structural and functional similarities between the corresponding freshwater and saltwater habitats were assumed as justification for this action. The 1981 LOOP Spill Effects Questionnaire results (Appendix C) were incorporated into the freshwater habitat tables.

The relative frequencies (rarity) of saltwater and freshwater habitats in the LOOP planning area are presented in Table 6. Estuarine open water was the major saltwater habitat, followed by brackish and salt marshes. The remaining five saltwater habitats accounted for only about 1% of the total area (Table 1). The dominant freshwater habitat was fresh marsh, composing nearly 75% of the total.

Table 3. Recovery period of saltwater and freshwater habitats. Relative values are applied to recovery periods reported in the literature: 1 = structural recovery in 1 year or less; 2 = between 1 and 3 years; 3 = longer than 3 years.

Habitat	Relative rank value	Total	Mean rank
Saltwater			
Saltwater swamp	3[a] [b] [c] [d]	12	3
Brackish marsh	2[e] [f] 1[g] [h] [i]	7	1.4
Saltwater marsh	2[e] [f] 1[g] [h] [i]	7	1.4
Saltwater aquatic bed	2[a] 1[j]	3	1.5
Mud/sand flats			1*
Estuarine open water			1*
Sand beach			1*
Shell beach			1*
Freshwater			
Freshwater swamp	3[a] [b] [c] [d] 2.7[+]	14.7	2.9
Freshwater marsh	2.5[+] 2[e] [f] 1[g] [h] [i]	9.5	1.6
Freshwater aquatic bed	2[a] 1[j] 1.8[+]	4.8	1.6
Fresh open water	1.2[+]	1.2	1.2

[a] Nadeau and Berquist 1977
[b] Chan 1977
[c] Getter et al. 1981
[d] Lugo 1981
[e] Hershner and Moore 1977
[f] Krebs and Tanner 1981
[g] Lindstedt-Siva 1981
[h] Baker 1970
[i] Baker 1971b
[j] Anonymous 1969

*Assumed minimum rating for abiotic substrate.
[+] Mean values taken from 16 responses to the 1981 LOOP Spill Effects Questionnaire.

Table 4. Persistence of oil in saltwater and freshwater habitats. Relative values are applied to length of time oil persists in the habitat as reported in the literature: 1 = oil persists for 1 year or less; 2 = between 1 and 3 years; 3 = longer than 3 years.

Habitat	Relative rank value	Total	Mean rank
Saltwater			
Saltwater swamp	3[a, b, c, d, e]	15	3
Brackish marsh	2[d, f, g] 3[h, i]	12	2.4
Saltwater marsh	2[d, f, g]	12	2.4
Saltwater aquatic bed	1[b, d, j]	3	1
Mud/sand flat	2[h]	2	2
Estuarine open water			1*
Sand beach	1[a, d, h, k, l]	5	1
Shell beach	1[m] 2[d, h, k]	10	2
Freshwater			
Freshwater swamp	2.6[+] 3[a, b, c, e, n]	17.6	2.9
Freshwater marsh	2[f, g, n] 2.4[+] 3[h, i]	14.4	2.4
Freshwater aquatic bed	1[b, c, n] 2.1[+]	5.1	1.5
Fresh open water	1.3[+]	1.3	1.3

[a] Chan 1977
[b] Nadeau and Berquist 1977
[c] Getter et al. 1981
[d] Gundlach et al. 1975
[e] Lugo 1981
[f] Lytle 1975
[g] Hershner and Moore 1977
[h] Gundlach et al. 1981b
[i] Hann 1977
[j] Clark 1973
[k] Gundlach et al. 1978
[l] Hayes et al. 1975
[m] Gundlach et al. 1981b
[n] Gundlach and Hayes 1978
[*] Assumed minimum rating for abiotic substrate.
[+] Mean values taken from 16 responses to the 1981 LOOP Spill Effects Questionnaire.

Table 5. Cleanup damage to saltwater and freshwater habitats. Relative values are applied to degree of damage to the habitat resulting from attempted cleanup as reported in the literature: 1 = cleanup can be accomplished with little or no further damage; 2 = cleanup causes moderate habitat disruption; 3 = cleanup causes extensive habitat destruction.

Habitat	Relative rank value	Total	Mean rank
Saltwater			
Saltwater swamp	3[a,b]	6	3
Brackish marsh	3[c,d]	6	3
Saltwater marsh	3[c,d,e,f,g,h,i]	12	3
Saltwater aquatic bed			3[a]
Mud/sand flat	2[c,f] 3[g]	7	2.3
Estuarine open water			1*
Sand beach	1[c,j] 2[g]	4	1.3
Shell beach	1[c] 2[g]	3	1.5
Freshwater			
Freshwater swamp	3[a,b] 2.8[+]	8.8	2.9
Freshwater marsh	3[c,d,e,f,h,i,j] 2.8[+]	23.8	3.0
Freshwater aquatic bed	2.4[+]	2.4	2.4
Fresh open water	1.2[+]	1.2	1.2

[a] Castle 1977
[b] Holt et al. 1978
[c] Lindstedt-Siva 1979a
[d] Lindstedt-Siva 1979b
[e] McCauley and Harrel 1981
[f] Hayes et al. 1978
[g] Gundlach et al. 1978
[h] Westree 1977
[i] Baker 1971a
[j] Gundlach and Hayes 1978

[*] Assumed rating.
[+] Mean values taken from 16 responses to the 1981 LOOP Spill Effects Questionnaire.

Table 6. Rarity of saltwater and freshwater habitats in the LOOP planning area.[a] Value based on the relative frequency of the habitat: 1 = relative frequency greater than 50% of the total area; 2 = relative frequency of 11% to 50%; 3 = relative frequency of 0% to 10%.

Habitat	Relative rank value
Saltwater	
Saltwater swamp	3
Brackish marsh	2
Saltwater marsh	2
Saltwater aquatic bed	3
Mud/sand flat	3
Estuarine open water	1
Sand beach	3
Shell beach	3
Freshwater	
Freshwater swamp	2
Freshwater marsh	1
Freshwater aquatic bed	3
Fresh open water	3

[a] Area of each habitat and percentage of total within the LOOP planning area are listed in Table 1.

Habitat use by the species of concern (Table 7) required extensive enumeration and classification of the species. Appendix B details the methodology used. Of the saltwater habitats, brackish marsh was used the most by the species of concern. Of the freshwater habitats, marsh and open water were used most.

Table 7. Saltwater and freshwater habitat use by species of concern. Number and percent of species occurring in the habitat are presented for each species category. Rank is a relative value based on the mean percent of species of concern supported by a habitat: 1 = 0% to 25%; 2 = 26% to 50%; 3 = more than 50%. See Appendix B for methods to determine species categories and number of species per category.

Habitats	Commercial (N=16)		Endangered (N=2)		Sport (N=38)		Nongame birds (N=96)		Mean percentage	Rank
	Total	%	Total	%	Total	%	Total	%		
Saltwater										
Saltwater swamp	0	0	1	50	1	3	11	11	16	1
Brackish marsh	11	69	1	50	27	71	31	32	55	3
Saltwater marsh	6	37	1	50	11	29	41	43	40	2
Saltwater aquatic bed	4	25	0	0	23	61	6	6	23	1
Mud/sand flats	6	37	1	50	18	47	39	41	44	2
Estuarine open water	6	37	1	50	22	58	52	54	50	2
Sand beaches	0	0	1	50	1	3	31	32	21	1
Shell beaches	0	0	1	50	0	0	10	10	15	1
Freshwater										
Freshwater swamp	9	56	1	50	9	24	39	41	43	2
Freshwater marsh	11	68	1	50	24	63	50	52	58	3
Freshwater aquatic bed	6	37	0	0	22	58	19	20	29	2
Fresh open water	13	81	1	50	20	53	31	32	54	3

The mean values for each criteria (Tables 3-7) are listed by habitat in the summary Table 8. The summation of the means resulted in a total number that ranged between 5 and 15. A maximum total of 15 would indicate a habitat that would suffer the greatest ecological impacts from an oil spill. Each habitat in the freshwater and saltwater categories was assigned a priority ranking in correspondence to the numerical ranking of the totals from high to low values.

The resulting spill protection priority rankings are presented in Table 9. In both freshwater and saltwater habitats, swamps received the highest priority for spill protection and marshes received the next highest priority. Open water received the lowest protection priority.

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Table 8. Summary of criteria evaluations for saltwater and freshwater habitats. Values for each criteria are the mean values for each habitat from Tables 3-7. The priority ranking assigned to each habitat corresponds to the numerical ranking of the totals from high to low values.

	Relative ranking value						
	Criteria						
	Habitat recovery	Persistence of oil	Cleanup damage	Habitat rarity	Important species supported	Total	Spill protection priority ranking
Saltwater							
Saltwater swamp	3	3	3	3	1	13	1
Brackish marsh	1.4	2.4	3	2	3	11.8	2
Saltwater marsh	1.4	2.4	3	2	2	10.8	3
Saltwater aquatic bed	1.5	1	3	3	1	9.5	5
Mud/sand flats	1	2	2.3	3	2	10.3	4
Estuarine open water	1	1	1	1	2	6	8
Sand beach	1	1	1.3	3	1	7.3	7
Shell beach	1	1.8	1.5	3	1	8.3	6
Freshwater							
Freshwater swamp	2.9	2.9	2.9	2	2	12.7	1
Freshwater marsh	1.6	2.4	3.0	1	3	11.0	2
Freshwater aquatic bed	1.6	1.5	2.4	3	2	10.5	3
Fresh open water	1.2	1.3	1.2	3	3	7	4

Table 9. Spill protection priority ranking for saltwater and freshwater habitats within the LOOP planning area. A rank of 1 indicates highest priority for spill protection.

Rank	Habitat	Rank	Habitat
	Saltwater		Freshwater
1	Saltwater swamp	1	Freshwater swamp
2	Brackish marsh	2	Freshwater marsh
3	Saltwater marsh	3	Freshwater aquatic bed
4	Mud/sand flats	4	Fresh open water
5	Saltwater aquatic bed		
6	Shell beach		
7	Sand beach		
8	Estuarine open water		

RECOMMENDATIONS FOR USE OF THE HABITAT RANKING METHOD

The habitat priority ranking methodology described above can be used to aid spill response coordinators with limited personnel, materials, and equipment to assign priorities and develop protection strategies. The ranking should be incorporated into a complete contingency plan. Such a plan will consider spill dynamics, containment and protection methods, and recovery and removal methods as they relate to the geographic area of concern.

Normally, the overriding consideration in a spill event is the operational feasibility of protecting specific areas. Cartographically accurate base maps (and habitat maps in many coastal regions) are available at a scale of 1:24,000. We recommend that spill response atlases be compiled using these bases. Recommended overlays would include the priority ranked habitats along with other mappable information such as bird colonies, habitat critical to endangered species, recreation sites (e.g., marinas and high-use beaches), industrial use areas, and other areas of special concern with an indication of their temporal use patterns.

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APPENDIX A

Habitat Groupings

The habitats for oil spill priority ranking in the LOOP planning were grouped as described below. The alphanumeric code names were adapted from Cowardin et al. (1979) as used by Wicker et al. (1980).

Habitat	Code
Saltwater Swamp	E2SS3
Brackish Marsh	E2EM5P5 E2EM5P5d E2EM5P6 E2EM5P6d
Saltwater Marsh	E2EM E2EMd E2EM5N4 E2EM5N4d E2EM5N45
Saltwater Aquatic Bed	E1AB E1AB1 E1AB2 E1AB12 E1AB5 E1AB5h E1AB5o E1AB5x
Mud and Sand Flats	E2FL E2FL2 E2FL3 E2FL34 E2FL23 E2FL24 M2FL2
Estuarine Open Water	E1OW E1OWt E1OWx E1OWh E1OWo E2OW E1OW4 E1UB2 E2UB34
Sand Beaches	E2BB2 M2BB2
Shell Beaches	E2RF2 E2RF2r
Freshwater Swamp	PFO34 PFO12 PFO24 PFO1 PFO13 PFO123 PFO134 PFO5
Freshwater Marsh	PEM PEMd
Freshwater Aquatic Bed	PAB PAB2 PAB5 PAB5X PAB5o L2AB L2AB2 L2AB5 L2AB5h L2AB5X L2AB2h
Fresh Open Water	POW POW4 POWo POWx POWh L1OW L2OW L2OWx L2OWh L2OWo L2OW4 L2OWh

APPENDIX A

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APPENDIX B

Ranking Procedures for Habitat Support of Important Species

The habitats within the LOOP area differ in the number of wildlife species they support. Some are used by a large variety of species while others are used by relatively few. To minimize the ecological damage resulting from oil spills, these differences between the habitats must be considered.

It is important to note that we are not discussing the effects of oil on individual species. We are discussing the relative effects to wildlife that damage to a habitat would cause. It would be false to think that only species directly contaminated by oil are effected by an oil spill. Damage that reduces the life-supporting value of a habitat will ultimately affect all organisms occurring there.

The procedures used for ranking the habitats according to their relative support for wildlife are summarized and described below.

A. Determination of species to be considered

B. Determination of habitats used by these species

C. Totaling the number of species using each habitat

D. Ranking habitats according to the number of species occurring there, high priority being given to those habitats which support the largest number of species.

A. Determination of Species to be Considered

Though all species will be affected by loss or damage to the habitat in which they live, it is impractical to consider every vertebrate and invertebrate in a given area. We have considered four categories of species to be the most important since they, for various reasons, have distinct value to man. These are endangered species, commercial species, sport species and non-game birds. In this study, each of these four categories receives equal weight in the final ranking. However, applications of this method to other areas could involve weighting factors for any particular group.

For each of these four categories, a list was generated of the species regularly occurring in the LOOP study area. Species that are rare or only brief visitors were not included. The rationale for the species included in each category is briefly discussed below.

Endangered species. Two endangered species use habitats in the LOOP area: the brown pelican and the bald eagle. Though bald eagles currently nest outside the LOOP study area, nesting territories are within 5 mi (8 km) of the study area boundaries and the prospects of current or future use of LOOP habitats by the eagles warrant consideration of this important species. (U.S. Fish and Wildlife Service 1979). The brown pelican currently nests within a small section of the LOOP area. Goals for recovery are to expand its current range.

Commercial species. We have selected 16 of the major commercial species using habitats within the LOOP area. Though this list is not complete, it is intended to represent the major finfish, shellfish, and furbearers of the area. The alligator is a recent inclusion to this category as it is now commercially harvestable in the Louisiana coastal marshes. It remains an endangered species elsewhere.

All species within this category receive equal weight and there are no weighting factors based on the size of the commercial industries involved. Our intent was to represent a wide diversity of commercially harvestable species that involves a large number of the southern Louisiana populace.

Sport species. The major sport species in the LOOP area are fish, waterfowl, and deer. Again, there is no weight given to any particular species as the goal is to maintain the diversity of sport species as a whole. Thirty-eight species have been included in this category.

Nongame birds. Nongame birds are those protected by the Migratory Bird Conservation Act and which are enjoyed as recreation by naturalists, photographers, and bird watchers. We have included this category due to the legal protection, high visibility, extensive data base, and large user groups associated with birds. Ninety-six species are included in this category.

B. Determination of Habitats Used

Habitats used by species of concern are listed in Tables B-1 through B-4. References used to obtain habitat information are listed at the end of this section. Observations made during aerial surveys of breeding bird colonies in the LOOP area were also used to confirm and supplement the literature records. In all cases an effort was made to be as specific for the LOOP area as possible.

C. Totals of Species Using Each Habitat

For each of the four categories (commercial, endangered, sport, and nongame), the number of species using each habitat was counted. These totals were then represented as percentages of the total number of species in the category (Table B-5). This transformation ensures that each category receives a value that is not biased by the number of species considered. The percentages of each of the four categories were then totalled and averaged to arrive at a final value reflecting the support that habitat provides for species of concern.

D. Ranking the habitats

The final percentages for each habitat were ranked according to the following criteria.

(1) Low - (0% to 24%) - on an average, less than one quarter of the species considered in any category occur in this habitat

(2) Medium - (25% to 50%) - on an average, one quarter to a half of the species considered in any category occur in this habitat

(3) High - (51% to 100%) - on an average, over half of the species considered in any category occur in this habitat

These final ranks are then included with the other criteria (Table 8) to determine a final overall rank for each habitat.

Table B-1. Habitats of commercial species.

Species supported	Saltwater								Freshwater			
	Swamp	Brackish marsh	Marsh	Aquatic bed	Mud/sand flats	Estuarine open water	Sand beach	Shell beach	Swamp	Marsh	Aquatic bed	Open water
American oyster		X			X	X						
Brown shrimp		X	X	X	X	X						
White shrimp		X	X	X	X	X						
River crayfish									X	X		X
Red swamp crayfish									X	X	X	X
Blue crab		X	X		X	X				X		X
Channel catfish		X							X	X	X	X
Blue catfish		X							X	X	X	X
Gulf menhaden		X	X	X	X	X						X
Atlantic croaker		X	X	X	X	X						X
Alligator		X							X	X	X	X
Nutria		X							X	X	X	X
Muskrat		X	X							X	X	X
Raccoon									X	X		X
River otter									X	X	X	X
Mink									X		X	X
TOTAL	0	11	6	4	6	6	0	0	9	11	6	13

Table B-2. Habitats of endangered species.

	Saltwater								Freshwater			
Species supported	Swamp	Brackish marsh	Marsh	Aquatic bed	Mud/ sand flats	Estuarine open water	Sand beach	Shell beach	Swamp	Marsh	Aquatic bed	Open water
Bald eagle		X	X						X	X		X
Brown pelican	X				X	X	X	X				
TOTAL	1	1	1	0	1	1	1	1	1	1	0	1

Table B-3. Habitats of sport species.

Species supported	Saltwater								Freshwater			
	Swamp	Brackish marsh	Marsh	Aquatic bed	Mud/ sand flats	Estuarine open water	Sand beach	Shell beach	Swamp	Marsh	Aquatic bed	Open water
Whitefronted goose										X	X	X
Lesser snow (blue) goose		X		X	X	X				X	X	X
Mallard				X	X	X			X	X	X	X
Mottled duck		X	X	X	X	X				X	X	X
Gadwall		X	X	X	X	X				X	X	X
Northern pintail		X		X	X	X				X	X	X
Green-winged teal		X		X	X	X				X	X	X
Blue-winged teal		X	X	X	X	X				X	X	X
American wigeon		X	X	X	X	X				X	X	X
Northern shoveler		X		X	X	X				X	X	X
Wood duck		X							X	X	X	X
Redhead		X		X	X	X						X
Ring-necked duck		X		X	X	X				X	X	X
Canvasback		X		X	X	X				X	X	X
Lesser scaup		X	X	X		X						X
Common goldeneye				X		X						
Bufflehead				X		X						
Ruddy duck				X		X					X	X
Common merganser												X
Red-breasted merganser						X						
Hooded merganser	X	X				X						
King rail		X	X							X	X	
Clapper rail		X	X									

Table B-3 (Concluded).

Species supported	Saltwater								Freshwater			
	Swamp	Brackish marsh	Marsh	Aquatic bed	Mud/ sand flats	Estuarine open water	Sand beach	Shell beach	Swamp	Marsh	Aquatic bed	Open water
Virginia rail		X	X	X	X					X	X	
Sora rail		X	X	X						X	X	
Purple gallinule									X	X	X	
Common gallinule										X	X	
American coot		X		X		X			X	X		X
American woodcock									X			
Snipe		X			X					X		
Mourning dove				X		X						
Swamp rabbit									X	X		
White-tailed deer		X							X	X		
Red drum		X	X	X	X	X						
Southern flounder		X	X	X	X	X						
Spotted sea trout		X	X	X	X	X						
Crappie		X							X	X	X	X
Largemouth bass		X							X	X	X	X
TOTAL	1	27	11	23	18	22	1	0	9	24	22	20

Table B-4. Habitats of nongame birds.

Species supported	Saltwater								Freshwater			
	Swamp	Brackish marsh	Marsh	Aquatic bed	Mud/ sand flats	Estuarine, open water	Sand beach	Shell beach	Swamp	Marsh	Aquatic bed	Open water
Common loon						X						X
Horned grebe						X						
Pied-billed grebe						X				X	X	X
White pelican					X	X						
Double-crested cormorant		X	X			X			X	X		X
Olivaceous cormorant	X	X	X						X		X	X
Anhinga									X	X		X
Great blue heron		X	X		X				X	X	X	X
Green heron		X	X		X				X	X	X	X
Little blue heron		X	X						X	X	X	X
Cattle egret		X	X		X				X	X	X	X
Reddish egret	X		X		X	X					X	
Great egret	X	X	X		X	X			X	X	X	X
Snowy egret		X	X			X					X	
Black-crowned night heron	X	X	X			X			X	X	X	X
Yellow-crowned night heron	X	X	X		X	X			X	X	X	X
Least bittern		X	X			X			X	X	X	
American bittern		X	X			X			X	X	X	
Wood stork	X			X					X	X	X	X
Glossy ibis	X	X	X		X	X			X	X	X	X
White-faced ibis		X	X			X			X	X	X	X

(continued)

Table B-4 (Continued).

	Saltwater								Freshwater			
Species supported	Swamp	Brackish marsh	Marsh	Aquatic bed	Mud/ sand flats	Estuarine open water	Sand beach	Shell beach	Swamp	Marsh	Aquatic bed	Open water
Louisiana heron	X	X	X		X	X			X	X	X	X
White ibis	X	X	X		X	X			X	X	X	X
Roseate spoonbill	X	X	X			X				X	X	X
Swallow-tailed kite									X	X		X
Red-tailed hawk									X	X		
Red-shouldered hawk									X			X
Northern harrier										X		
Osprey			X							X		X
Black-necked stilt	X	X		X	X	X	X			X		X
American avocet					X	X				X	X	X
Semipalmated plover			X		X	X	X					
Wilson's plover					X	X	X					
Piping plover					X	X	X					
Black-bellied plover			X		X	X	X					
Marbled godwit			X		X	X	X					
Greater yellowlegs			X		X	X	X			X		X
Lesser yellowlegs			X		X	X	X			X		X
Willit			X		X	X	X					
Spotted sandpiper					X	X	X					
Ruddy turnstone					X	X	X					
Short-billed dowitcher		X	X		X	X				X		
Long-billed dowitcher		X	X		X	X	X			X		

(continued)

Table B-4 (Continued).

Species supported	Saltwater								Freshwater			
	Swamp	Brackish marsh	Marsh	Aquatic bed	Mud/ sand flats	Estuarine open water	Sand beach	Shell beach	Swamp	Marsh	Aquatic bed	Open water
Red knot					X	X	X					
Sanderling					X	X	X					
Semipalmated sandpiper				X	X	X	X					
Western sandpiper				X	X	X	X					
Least sandpiper					X	X	X					
White-rumped sandpiper					X	X	X					
Pectoral sandpiper		X		X	X	X	X			X		
Dunlin					X	X	X					
Stilt sandpiper			X	X	X	X	X					
Herring gull					X	X	X	X				
Ring-billed gull					X	X	X	X				
Laughing gull			X		X	X	X	X				
Bonaparte's gull			X	X	X	X						
Gull-billed tern			X			X	X	X				
Forster's tern			X			X						
Common tern						X	X	X				
Least tern						X	X	X				
Royal tern						X	X	X				
Sandwich tern						X	X	X				
Caspian tern						X	X	X				
Black skimmer						X	X	X				
Marsh wren		X								X		
Sedge wren		X	X							X		

(continued)

Table B-4 (Continued).

Species supported	Saltwater								Freshwater			
	Swamp	Brackish marsh	Marsh	Aquatic bed	Mud/ sand flats	Estuarine open water	Sand beach	Shell beach	Swamp	Marsh	Aquatic bed	Open water
White-eyed vireo									X			
Prothonotory warbler									X			
Parula warbler									X			
Yellow-throated warbler									X			
Common yellowthroat									X			
Hooded warbler									X			
Red-winged blackbird									X	X		
Rusty blackbird									X			
Boat-tailed grackle	X	X	X		X					X		
Savannah sparrow		X	X		X					X		
LeConte's sparrow										X		
Sharp-tailed sparrow		X	X							X		
Seaside sparrow			X									
Swamp sparrow									X	X		
Song sparrow									X	X		
Barn owl									X	X		
Screech owl									X	X		
Great horned owl									X	X		X
Barred owl									X			
Short-eared owl		X	X							X		
Belted kingfisher		X	X							X		
Pileated woodpecker									X			
Red-bellied woodpecker									X			

(continued)

Table B-4 (Concluded).

Species supported	Saltwater								Freshwater			
	Swamp	Brackish marsh	Marsh	Aquatic bed	Mud/sand flats	Estuarine open water	Sand beach	Shell beach	Swamp	Marsh	Aquatic bed	Open water
Eastern kingbird										X		
Eastern phoebe									X			
Acadian flycatcher									X			
Tree swallow										X		X
Bank swallow										X		X
Barn swallow										X		X
Fish crow		X	X							X		X
TOTAL	11	31	41	6	39	52	31	10	39	50	19	31

Table B-5. Summary of habitats for species of concern in the LOOP area.

Habitats	Commercial (N=16)		Endangered (N=2)		Sport (N=38)		Nongame birds (N=96)		Total percentage	Mean percentage	Rank
	Total	%	Total	%	Total	%	Total	%			
Saltwater											
Saltwater swamp	0	0	1	50	1	3	11	11	64	16	1
Brackish marsh	11	69	1	50	27	71	31	32	222	56	3
Saltwater marsh	6	37	1	50	11	29	41	43	159	40	2
Saltwater aquatic bed	4	25	0	0	23	61	6	6	92	23	1
Mud and sand flats	6	37	1	50	18	47	39	41	175	44	2
Estuarine open water	6	37	1	50	22	58	52	54	199	50	2
Sand beaches	0	0	1	50	1	3	31	32	85	21	1
Shell beaches	0	0	1	50	0	0	10	10	60	15	1
Freshwater											
Freshwater swamp	9	56	1	50	9	24	39	41	171	43	2
Freshwater marsh	11	68	1	50	24	63	50	52	233	58	3
Freshwater aquatic bed	6	37	0	0	22	58	19	20	115	29	2
Fresh open water	13	81	1	50	20	53	31	32	216	54	3

APPENDIX B

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APPENDIX C

Questionnaire Package Used to Poll Biologists With Oil Spill Experience

Dear :

Please take a few moments from your busy schedule to fill out the attached questionnaire. This questionnaire has been developed in an effort to solicit information in addition to the published literature on the effects of crude oil spills in certain coastal and aquatic habitats for use in contingency planning. Although there is a considerable volume of information on oil spill impacts, habitat-specific information (particularly freshwater habitats) is not readily available in published form. The information base we wish to access with this questionnaire exists as personal observations and working experiences with spills in various habitats.

The questionnaire has been designed as a matrix to rate nine different habitats for each of three impact criteria. The impact criteria and ranking system are defined below.

Thanks in advance for your assistance.

Enclosure

Questionnaire - IMPACT EVALUATION FOR CRUDE OIL SPILLS ON CERTAIN COASTAL AND AQUATIC HABITATS.

Please fill out the matrix below, ranking each impact criterion as high (H), medium (M), or low (L). Assume moderate to heavy oiling.

If you are not familiar with a certain habitat, please leave it blank. Your comments and observations on any spills actually witnessed would be appreciated.

	HABITATS											
Impact Criteria	Freshwater Swamp	Freshwater Marsh	Freshwater Aquatic Bed (e.g., widgeon grass)	Fresh Open Water	Saltwater Swamp (e.g., mangrove)	Brackish Marsh	Saltwater Marsh	Saltwater Aquatic Bed (e.g., turtle grass)	Saltwater Flats	Estuarine Open Water	Sand Beach	Shell Beach
Habitat Recovery												
Persistence of Oil												
Cleanup Damage												

Comments:

50272-101

REPORT DOCUMENTATION PAGE

1. REPORT NO. FWS/OBS-82/61

2.

3. Recipient's Accession No.

4. Title and Subtitle A METHOD FOR RANKING BIOLOGICAL HABITATS IN OIL SPILL RESPONSE PLANNING AND IMPACT ASSESSMENT

5. Report Date August 1984

6.

7. Author(s)
J.K. Adams, K.A. Benkert, C. Keller and R. White

8. Performing Organization Rept. No.

9. Performing Organization Name and Address
National Coastal Ecosystems Team
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Slidell, LA 70458

10. Project/Task/Work Unit No.

11. Contract(C) or Grant(G) No.
(C)
(G)

12. Sponsoring Organization Name and Address
National Coastal Ecosystems Team
Division of Biological Services
Fish and Wildlife Service
U.S. Department of the Interior, Washington, DC 20240

13. Type of Report & Period Covered

14.

15. Supplementary Notes

16. Abstract (Limit: 200 words)

The report describes a method that enables oil spill response planners to minimize the ecological impacts of oil spills by determining protection priorities for biological habitats. The objective of the method is to allow persons responding to an oil spill to quickly identify areas that should be protected first, second, and on to the extent that personnel and equipment are available. The first part of the report describes the rationale and general components of the method. The last part presents an application of the method to the Louisiana Offshore Oil Port (LOOP) spill response planning area.

17. Document Analysis a. Descriptors

Habitat, Ranking, Ecology

b. Identifiers/Open-Ended Terms

Oil spills

c. COSATI Field/Group

18. Availability Statement
Unlimited

19. Security Class (This Report)
Unclassified

20. Security Class (This Page)
Unclassified

21. No. of Pages
42

22. Price

(See ANSI–Z39.18)

See Instructions on Reverse

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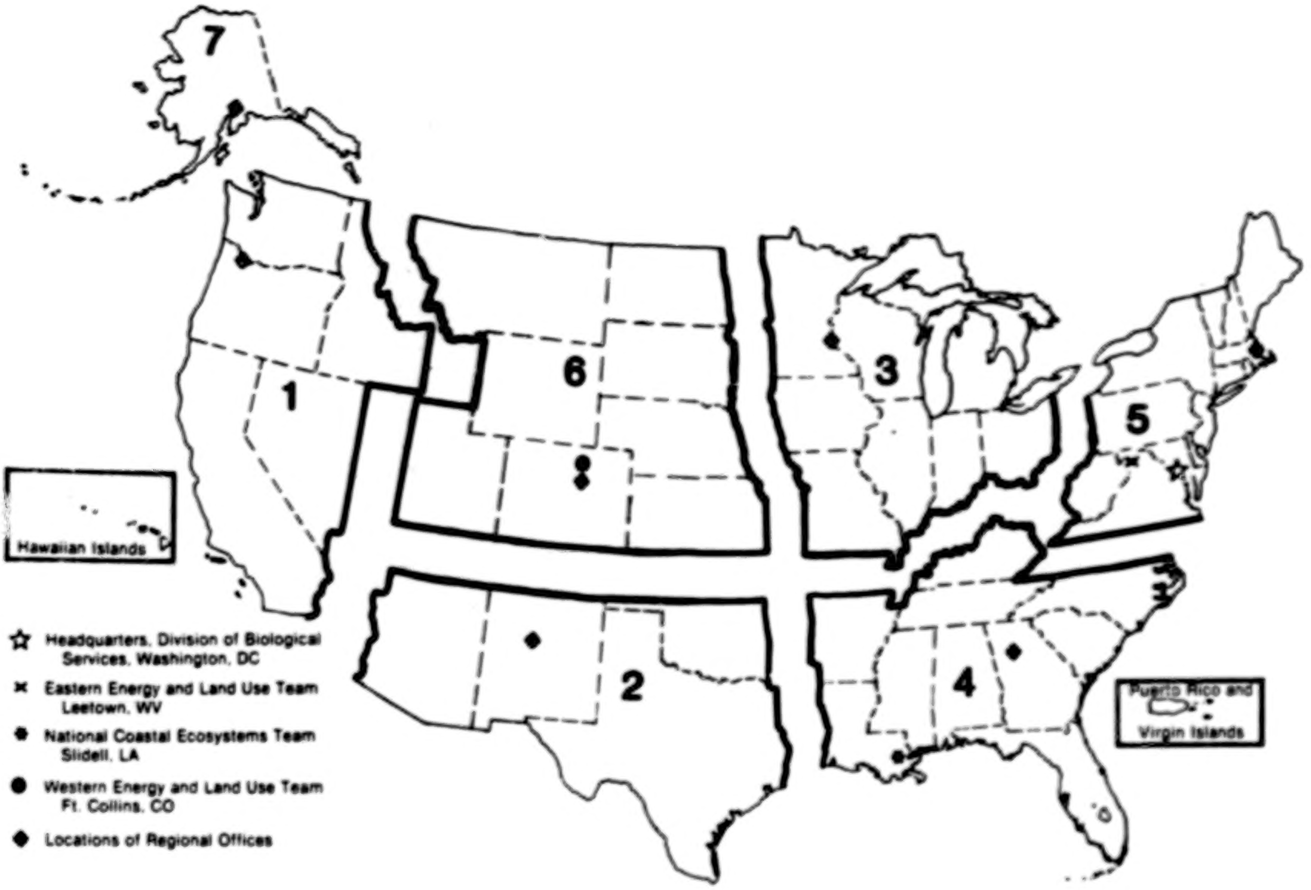
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Hawaiian Islands
Puerto Rico and Virgin Islands
☆ Headquarters, Division of Biological Services, Washington, DC
× Eastern Energy and Land Use Team Leetown, WV
● National Coastal Ecosystems Team Slidell, LA
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